ICANS XX,
20th meeting on Collaboration of Advanced Neutron Sources
March 4 – 9, 2012
Bariloche, Argentina

Characterization of a Directionally Enhanced Moderator

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Abstract

We describe measurements characterizing a directionally-enhanced moderator design in which a moderating material (in this case polyethylene) is interleaved with layers of single crystal (in this case silicon). The largely transparent crystalline layer provides a preferred escape path from deep within the moderator; an extension of the re-entrant moderators that have been deployed at neutron sources for some time, but with this technique the grooves may be constructed far more efficiently (neutronically), and easily (mechanically). Such a moderator provides increased neutron brightness, especially at longer wavelengths, at small angles relative to the interface between the moderating and nonmoderating layers. This increased brightness, when aligned with neutron beam lines, will result in large increases in the beam intensity extracted from the moderator. Measurements at room temperature demonstrate two aspects of the hypothesized gain factors; the geometric gain factor (present whether the non-moderating layers are single crystal or vacuum), peaking at about a 35-40% gain in brightness, with a reasonable average of greater than 20% over a one degree angular range, centered slightly less than one degree to either side of the plane of the non-moderating layer. We also observe enhanced intensity at specific wavelengths as dictate by the crystal orientation of the nonmoderating layers (the so-called Bragg gains). These gains are small, less than 10% at best, and are present only within the emission plane precisely corresponding to the nonmoderating layer, not in the same direction as the more useful geometric gains. Simultaneous measurements of pulse shapes indicate that the increased intensity from the geometric gain comes in the more desirable “peak intensity” portion of the emission time distribution, and not in increased pulse width / long-time tails. Measurements at reduced temperature indicate that the geometric gains may be even more dramatic. We also describe ongoing efforts to characterize the final class of gains hypothesized from such a moderator, associated with refractive effects at the interfaces between the moderating and non-moderating layers (the so-called refractive gains).